Potential Trees for Bio-Diesel Production©

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WHY BIO-FUELS?

- Shrinking supply of fossil fuels and the increasing demand for energy in 2005.
- In the global economy it could lead to an oil crisis in the future.
- The enforcement of the Kyoto Protocol drives towards using bio-fuels to offset CO_2 emissions. As a result the possibility of earning additional revenue through bio-fuel projects in the form of "Certified Emission Reductions" is certain.
- This form of funding contributes towards the financial feasibility of tree projects for bio-diesel.
- The potential of alleviating poverty in South Africa's rural areas with the production of a needed product bio-diesel while reducing greenhouse gas emissions is a solution to many of Africa's problems.

THE FOLLOWING SHOULD BE TAKEN INTO CONSIDERATION WHEN TREES ARE CHOSEN

- High potential agricultural land is reserved for food crops, and the threat towards "food security" from bio-fuel crops is taken seriously.
- However, marginal land not suited for agricultural purposes, such as rehabilitated mines and degraded land due to overgrazing and mis-management, are areas which could be made available for the cultivation of trees suitable for bio-diesel production.

TREE SEED OIL CONCEPT

- Advantages: Drought resistant.
- Require low input and maintenance.
- Yields of trees increase annually compared to annual agricultural crops.
- Establish by-products within the process.
- Energy plantations.
- Absorbs tons of carbon, thus reducing the greenhouse gas emissions.
- Provides infrastructure and income generating opportunities for rural poor communities.

POTENTIAL TREES SPECIES

Jatropha curcas.

- A small tree or large shrub, which can reach a height of up to 5 m.
- It is found in the tropics and subtropics of Africa; parts of Southern Africa; South East Asia; South, Central, and North America; as well as the northern territory of Australia.

- It is drought resistant (as low as 200 mm per year).
- Grows in soils that are quite unfertile.
- Its branches contain latex.
- Its seeds are black, 2 cm long and 1 cm thick.
- Propagates easily from seeds and cuttings.
- Rapid growth rate.
- Many parts of the plant are used in traditional medicine.
- Seeds are toxic to humans and many animals.
- Seeds yield non-edible oil, with properties close to diesel.
- An acceptable smokeless lamp oil.
- Presscake contains curcin, a highly toxic protein.
- Potential problems with *Jathropa curcas*:
  (a) The plant's invader status requires investigation. If the plant is identified as an invader, it should be listed and categorized as such.
  (b) Feasibility studies will answer these concerns.
  (c) It is not frost tolerant.

Moringa oleifera (ben-oil tree, horse-radish tree).

- A small deciduous, fast-growing tree (5 to 10 m) reaching up to 6 m within the first year if not pruned.
- Native to India and Arabia but naturalized in many tropical countries such as Malawi, Tanzania, and parts of South Africa.
- Frost tolerant, but can be killed back to ground level by freezing temperatures. New growth from the trunk.
- Mean annual temperatures between 12.6 and 4 °C.
- Mean annual rainfall of at least 300 mm.
- It can adapt to a wide range of soil types but prefers a well-drained clay soil or loam.
- For rural communities it is a good source of protein, vitamins, and minerals.
- It is an excellent source of amino acids and its edible oil resembles olive oil.
- Its flowers are eaten or used to make tea. Leaves, pods, and roots are eaten as a vegetable.
- Fibre from the bark is used for making small ropes and mats.
- Its seeds are used in curry sauce for a seasoning relish.
- From the seeds of mature pods excellent cooking or lubricating oil is extracted.

Ximenia caffra (large sour plum).

- Deciduous tree, 6 m tall, bears reddish oval fruit (40 mm long).
- Distribution from Tanzania in the North to Kwazulu Natal (South Africa) in the South.
- Flowering time: August to October.
- Fruiting time November to February.
- Uses: Ailments common to rural communities due to poor sanitation.
- Leaf mixture — soothes inflamed eyes; orally to relieve abdominal pains and cramps.

- Root concoction — orally to cure diarrhea and to dress wounds.
- Decaying fruits — antibiotics extracted.
- Ointment to treat septic sores (Hutchings, 1996; VanWyk and Gericke, 2000).
- Extracts are fungicidal to candida species, secondary contaminant of the human body and opportunistic in diabetic and HIV/aids patients and in related diseases.
- Extracts also cure fever, palpitation, eaten raw, even though they are very sour.
- In rural communities, the fruit juice is added to maize meal or pounded tubers to make porridge.
- Fruits are also processed and consumed in the form of jams, desserts, and jellies.
- Average composition of fruit:
  - Fruit weight 12.4 g: Seed weight 2.4 g
  - National Food Research Institute results on nutritional value of fruit pulp (ripe fruit 100 g):
    - Protein 1.9 g
    - Fiber 0.9 g
    - Carbohydrate 17g
    - Magnesium 19 g
    - Iron 0.49 g
    - Potassium 558 mg
    - Riboflavin 3.02 mg
    - Nicotinic acid 0.48 mg
    - Vitamin C 68.2 mg
- Oil is pure, nondrying and is used for cosmetic purposes, in lamps and on leather for softening (VanWyk and Gericke, 2000).
- As a cosmetic, the oil is used for anointing the human body and for straightening hair (FOA, 1983; 1989).

***Pappea capensis* (jacket plum).**

- Tree grows from 3 to 9 m high.
- Widely distributed in Southern Africa.
- Tolerant to frost.
- In late summer, the round capsules split open to reveal black seeds surrounded by red layers of fruit flesh.
- Fruit flesh is translucent and jelly-like, with a sweet-sour flavour. It can be collected to make jelly and jam.

POTENTIAL INDIGENOUS TREES

- *Trichilia emetica* (Natal mahogany).
- *Sclerocarya birrea* (marula).

OIL CONTENT

- *Jatropha curcas* — 55%–60% of dry weight.
- *Moringa oleifera* — 30% of dry weight.
- *Ximenia caffra* — 65.7% of dry weight.
- *Pappea capensis* — 75% of dry weight.

RESEARCH AT UNIVERSITY OF PRETORIA

- Feasibility of trees for bio-diesel production.
- Plant material collection.
  - Import permits issued (Agricultural Pests Act No 36, 1983).
  - Botanical gardens.
  - Searching sites in Southern Africa.
- Propagation.
  - Seed propagation: requirements.
  - Cuttings: optimal rooting.
  - Tissue culture: uniform plant material.
  - Alternative propagation (shorten juvenile phase via grafting).
- Production efficiency and manipulation.
  - Establishment and cultivation: pruning, etc.
  - Fruit set efficiency, flower phenology, and flowering improvement.

RESEARCH HIGHLIGHTS ON SEED PROPAGATION

Ximenia caffra (large sourplum).

- Seed germination is unreliable.
- Time to germinate not yet scientifically determined.
- Low seedling survival rate.
- Storage effect on seed viability is not known.
- Light/temperature effects not yet determined.

- Effect of seed pre-treatment at different seed storage periods on germination.
  - Harvested fruits were stored in a cold room at 8 °C and randomly selected at intervals for de-pulping and for obtaining seeds.
  - Fruit storage treatments were: 0, 30, and 120 days.
- Seed pre-treatments were:
  - Water.
  - Gibberellic acid (0.05%).
  - Gibberellic acid (0.2%).
  - Potassium nitrate (0.2%).
  - Potassium dihydrogen orthophosphate (0.2%).
  - Cape Seed Primer (Primer made out of aqueous smoke and GA_3. The smoke primers were supplied impregnated on filter paper.)
  - Benzylaminopurine (0.5%).
  - Seeds were soaked for 24 h and left to dry at room temperature for 4 to 6 h before sowing in seedling trays filled with sterilized quartz sand.
  - Placed on benches in a mist propagation unit at University of Pertoria.
  - Daily root and shoot lengths and seed germination were recorded.
  - Seed vigour index (SVI) was calculated using the formula: (shoot length + root length) × germination %.

- Results showed that the fresh seeds (0 days storage) gave the best germination results: between 80% and 90%.
- With 30 days storage the germination rate went down to between 50% and 70%.
- With 120 days storage the germination rate fell to between 10% and 20%.
- The short life span and poor germination response following storage indicate that *X. caffra* seeds are recalcitrant.

VEGETATIVE PROPAGATION OF LARGE SOURPLUM

- No rooting of stem cuttings of large sourplum (*X. caffra*) occurs, possibly due to heavy release of exudates (phenols) into the growth medium.
- Air layering (6 months, no callus).
- Tissue culture, not yet successful.

RESEARCH HIGHLIGHTS ON VEGETATIVE PROPAGATION OF BUSHVELD CHERRY

A publication on *P. capensis* (bushveld cherry) plant regeneration protocol will soon be available based on the following researach:

- Rooting of stem cuttings and air layering.
  - Time period: September-December.
  - For rooting cuttings, treatments used were:
    - Hormone (with and without).
    - Type of wood (semi-hard and hardwood).
  - Cuttings were planted in seedling trays and rooted in a mist bed.
- For air-layering of branches, treatments used were:
  - Hormone (with or without).
  - Male/female.
  - North, south, east, west facing.
- Rooting of stem cuttings results:
  - *Pappea capensis* shed leaves to generate new ones.
  - Not all cuttings regenerated new leaves.
  - Rooting of cuttings was very poor for both male and female trees.
  - Out of 240 cuttings only two rooted.
  - Some cuttings died.
- Air layering results
  - 34/40 produced roots (female tree)
  - More roots are produced on female trees
  - Repeat air-layering experiments (autumn season)
  - Analyze stem cuttings and air-layer samples to determine the phenolic compound and concentration, etc.

PRESENT AND FUTURE RESEARCH: PROPAGATION

- At present *X. caffra* can only be propagated via seed. Clonal propagation is not possible via air-layering and tissue culture yet.
- In vitro propagation of *P. capensis* is feasible. Seed propagation and vegetative propagation via air-layering is possible. Plants are slow growing and therefore budding and grafting are at present researched.
- *Jatropha curcas* and *M. oleifera* reproduction (seed/vegetatively/ tissue culture) is feasible.

PRESENT AND FUTURE RESEARCH: SITE ESTABLISHMENTS

The following questions are addressed after site establishments:

- How much water does it take to keep a tree alive? If water is scarce, a close management of the water requirements of the trees in the orchard is required.
- How far apart should the trees be planted? The wider the spacing, the more soil and water are available.
- If drought/frost occurs, will the plant survive and return to full cropping?
- How large should the tree canopy be? Water use is reliably related to tree canopy size.
- In conclusion, the ultimate aim of the producer is to convert the energy of the sun into maximum yield per hectare of high quality seed with minimum input costs.
- Estimates of plant growth and efficiency through phenological observations, as well as growth and yield measurements are made in various ways in order to aid in finding out where solar energy goes after entering the system.

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LITERATURE CITED

FAO. 1983. Food and Fruit-bearing Forest Species, 1 Examples from Eastern Africa, FAO Forest Paper 44 , 83–86.

FAO. 1989. Household Food Security and Forest: An Analysis of Socio-Economic Issues, Forest, Trees and People, Food and Agricultural Organisation of the United Nations (FAO), Rome.

Hutching, A., A.H. Scott, G. Lewis, and **A.B. Cunningham.** 1996. Zulu Medicinal Plants, University of Natal, Pietermaritzburg.

Van Wyk, B.E., and **N. Gericke.** 2000. People's Plants. A Guide to Useful Plants of Southern Africa, Briza Publications, Pretoria.